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DENDROLOGICAL SCALES OF SPRUCE EUROPEAN OF 5–7TH GROUPS OF PLANTS IN THE TERRITORY OF BELARUS

Spruce forests belonging to 5–7th groups of plants have I–I^b class of bonitet and are the most productive. Dendrological scales of spruce forests have an extension 104 years (1888–1991). Index values in the spruce forests of the 5th group plantings ranged for late wood within 0.66–1.44, for early wood – 0.61–1.30, for tree-ring as a whole – 0.62–1.29. In spruce forests of 6th group index values fluctuated for late wood within 0.72–1.99, for early – 0.63–1.26, for tree-ring as a whole – 0.67–1.24. In spruce forests of 7th group index va-lues fluctuated for late wood within 0.47–1.58, for early – 0.41–1.86, for tree-ring as a whole – 0.42–1.75. Coef-ficients of variation of indices width of tree rings were as follows: for spruce plantations 5th group 13% for spruce 6th group – 11% for spruce 7th group – 18%, which corresponds to the lower rate of normal variation.

Key words: european spruce, dendrological scale, radial growth, late wood and early wood.

Introduction. Dendrological chronology used in many areas of sciences and fields (archeology, climatology, etc.). Dendrochronological dating method is suitable for tree trunks and their fragments, as well as products made of wood, if they retained a large enough number of growth rings from the source material.

Main part. The aim of the research, a dendrological scales for highly productive spruce forests of Belarus. To achieve this goal were selected material model 75 fir plant communities. According to the eco-floristic classification of spruce forests of Belarus [1], the most productive spruce forests are related to the 5–7th groups of plants and having I-value class I^b. High productivity of spruce forests of the 5th and 6th groups formed on automorphic soils, due to the high moisture supply, which is defined by an extended rhizosphere zone (1.5 m) with an average content of physical clay in it for more than 12%. Spruce forests 7th group semihydromorphic grow on soils, which are characteristic of the rhizosphere zone less power at an average grade of physical clay more than 6% and shallow groundwater (0.8–2.7 m).

To study the radial growth of spruce in each plot were selected cores from five wood trees I–II classes Kraft growth as the most responsive to changing environmental conditions. When measuring the width of the growth rings and their components scanned surface sections of cores, then the resulting images were processed using the program Adobe Photoshop CS6 Extended, allows to make the necessary measurements.

Changing the width of the tree rings to the age of spruce stands in Belarus can be expressed in the form of a curve described by a power function of the form $y = ax^b$ (where y – the width of the annual ring, mm; x – age spruce years; a and b – the statistical coefficients) with the following parameters (Table 1).

In order to eliminate the influence of age-related changes in the width of the growth rings and the building arboretums scales were calculated indexes. For this purpose, an average long-term curve, estimated by 20-year-old moving for five-year periods, with the expectation of extreme points of the long-term average by a smaller number of growth rings [2].

Table 1

Parameters of regression equations change the width of the annual ring of spruce of different ages

Bonitet	Group plantings	The values of coefficients	
		a	*b*
I	5	20.596	–0.6233
	7	24.468	–0.6685
I^a	6	40.007	–0.7651
	7	26.879	–0.6647
I^b	6	36.033	–0.6996

Table 2

Dendrological scale spruce plantations of 5th group

Year	Indices			Count trees, pieces	Year	Indices			Count trees, pieces
	late wood	early wood	annual ring			late wood	early wood	annual ring	
1991	1.18	0.98	1.02	24	1939	0.91	0.79	0.80	74
1990	1.00	1.09	1.07	44	1938	0.92	0.86	0.86	74
1989	0.95	1.01	1.00	64	1937	0.92	0.94	0.94	73
1988	1.04	0.99	1.00	84	1936	1.01	0.98	0.98	72
1987	0.89	0.96	0.94	84	1935	1.05	1.09	1.08	71
1986	0.90	0.85	0.86	84	1934	1.09	1.06	1.06	70
1985	0.87	0.92	0.91	84	1933	1.03	1.04	1.03	67
1984	0.91	0.98	0.97	84	1932	0.93	1.08	1.06	66
1983	1.15	1.14	1.14	84	1931	0.91	1.01	1.00	66
1982	1.01	1.05	1.05	84	1930	0.98	1.10	1.09	64
1981	1.02	0.90	0.92	84	1929	1.00	1.13	1.12	61
1980	0.66	0.73	0.71	84	1928	1.01	1.20	1.18	59
1979	0.87	0.69	0.72	84	1927	1.04	1.19	1.17	58
1978	0.83	0.92	0.90	84	1926	1.16	1.14	1.14	55
1977	1.04	0.98	0.99	84	1925	1.07	1.15	1.14	54
1976	1.03	1.00	1.01	84	1924	1.15	1.09	1.10	53
1975	1.44	1.02	1.08	84	1923	1.07	0.94	0.95	52
1974	1.07	1.13	1.12	84	1922	1.07	0.94	0.95	50
1973	1.09	1.02	1.03	84	1921	1.02	0.92	0.93	49
1972	0.93	1.21	1.17	84	1920	0.98	0.87	0.89	47
1971	1.04	1.06	1.06	84	1919	0.97	0.92	0.92	46
1970	1.01	1.25	1.21	84	1918	0.97	0.97	0.97	46
1969	0.98	1.06	1.05	84	1917	0.92	0.95	0.95	42
1968	1.01	0.99	1.00	84	1916	0.75	1.01	0.98	37
1967	1.08	0.92	0.94	84	1915	0.79	0.92	0.90	36
1966	0.87	0.95	0.94	84	1914	0.85	0.89	0.88	35
1965	0.81	0.76	0.77	84	1913	1.04	0.94	0.96	32
1964	0.79	0.84	0.83	84	1912	0.97	0.96	0.96	31
1963	1.00	0.97	0.97	84	1911	1.08	1.05	1.06	28
1962	0.94	1.08	1.06	84	1910	1.30	1.07	1.10	26
1961	1.10	1.06	1.07	84	1909	1.28	1.10	1.13	25
1960	0.90	0.94	0.94	84	1908	1.08	1.00	1.01	24
1959	0.88	1.08	1.05	84	1907	1.13	1.02	1.04	22
1958	1.10	1.06	1.06	84	1906	0.95	0.97	0.97	21
1957	1.16	1.10	1.11	84	1905	0.95	1.08	1.06	19
1956	1.09	0.98	0.99	84	1904	1.04	0.92	0.94	19
1955	1.02	1.04	1.04	84	1903	0.88	0.94	0.93	19
1954	0.95	0.88	0.89	83	1902	0.84	0.90	0.89	18
1953	1.08	0.94	0.96	82	1901	0.80	0.89	0.88	16
1952	0.88	0.80	0.81	79	1900	0.71	1.11	1.06	15
1951	0.85	1.01	0.99	79	1899	1.05	1.08	1.07	14
1950	0.97	1.15	1.13	79	1898	1.07	1.14	1.13	13
1949	1.09	1.15	1.14	78	1897	0.93	1.17	1.14	13
1948	1.14	1.21	1.20	78	1896	1.07	0.95	0.97	11
1947	1.19	1.24	1.23	77	1895	0.82	0.82	0.82	9
1946	1.16	1.30	1.29	77	1894	0.74	0.78	0.77	9
1945	1.08	1.24	1.22	76	1893	1.11	1.06	1.07	8
1944	1.07	1.01	1.02	76	1892	1.18	0.71	0.78	6
1943	1.04	0.91	0.92	76	1891	1.16	0.90	0.94	6
1942	0.90	0.73	0.75	75	1890	1.14	0.95	0.98	6
1941	0.71	0.61	0.62	74	1889	1.01	0.78	0.82	6
1940	0.79	0.74	0.75	74	1888	0.99	1.09	1.07	6

Table 3

Dendrological scale spruce plantations of 6th group

Year	Indices			Count trees, pieces	Year	Indices			Count trees, pieces
	late wood	early wood	annual ring			late wood	early wood	annual ring	
1991	0.92	0.89	0.89	30	1939	0.93	0.84	0.84	118
1990	1.00	1.06	1.05	62	1938	0.88	0.97	0.96	112
1989	1.05	1.15	1.13	130	1937	0.98	1.03	1.02	111
1988	1.14	0.98	1.01	140	1936	1.09	1.01	1.02	106
1987	0.95	0.87	0.88	140	1935	1.03	1.10	1.09	104
1986	1.05	0.88	0.91	140	1934	0.97	1.20	1.17	94
1985	0.96	0.98	0.98	140	1933	0.95	1.14	1.12	88
1984	0.83	0.99	0.96	140	1932	0.99	1.21	1.19	79
1983	0.89	1.22	1.17	140	1931	1.09	1.17	1.16	77
1982	0.95	1.17	1.14	140	1930	0.98	1.05	1.04	70
1981	1.01	1.07	1.06	140	1929	0.95	1.01	1.01	61
1980	0.81	0.74	0.75	140	1928	0.98	1.06	1.05	55
1979	0.98	0.76	0.79	140	1927	0.97	1.05	1.04	47
1978	1.08	0.87	0.90	140	1926	1.12	1.00	1.02	46
1977	1.09	0.97	0.99	140	1925	1.09	1.01	1.01	40
1976	0.95	0.95	0.95	140	1924	0.98	0.93	0.93	38
1975	1.06	1.06	1.06	140	1923	0.99	0.91	0.92	34
1974	1.05	1.13	1.12	140	1922	0.98	0.93	0.94	31
1973	1.14	0.93	0.96	140	1921	1.00	0.91	0.92	29
1972	1.02	1.01	1.02	140	1920	1.02	0.82	0.84	25
1971	0.92	0.99	0.98	140	1919	0.85	1.03	1.01	21
1970	0.89	1.05	1.03	140	1918	0.95	0.99	0.98	18
1969	0.97	0.95	0.95	140	1917	0.81	1.00	0.98	15
1968	1.02	0.92	0.93	140	1916	1.05	1.11	1.10	11
1967	0.98	0.93	0.94	140	1915	1.05	0.88	0.90	10
1966	1.00	1.04	1.04	140	1914	1.06	0.94	0.95	9
1965	0.90	0.87	0.87	140	1913	0.83	0.79	0.80	9
1964	0.86	0.88	0.88	140	1912	0.88	0.87	0.88	9
1963	0.87	1.01	0.99	140	1911	1.01	0.83	0.85	9
1962	1.04	1.19	1.17	140	1910	1.05	0.92	0.94	9
1961	1.15	1.17	1.17	140	1909	1.02	0.90	0.91	7
1960	1.03	1.01	1.02	140	1908	0.93	1.04	1.03	6
1959	1.01	0.98	0.98	140	1907	1.07	1.02	1.02	6
1958	1.16	1.09	1.09	140	1906	1.05	1.02	1.03	6
1957	1.19	1.06	1.07	140	1905	1.12	1.10	1.10	5
1956	1.16	0.93	0.95	140	1904	0.77	1.00	0.97	5
1955	0.94	0.95	0.95	140	1903	0.92	1.04	1.02	5
1954	0.94	0.92	0.92	140	1902	0.83	0.99	0.97	5
1953	0.96	0.99	0.99	139	1901	0.81	0.82	0.82	3
1952	0.93	0.97	0.97	139	1900	0.80	0.84	0.84	3
1951	0.95	1.03	1.02	139	1899	1.57	0.84	0.93	3
1950	0.88	1.17	1.14	139	1898	0.77	0.97	0.95	3
1949	0.95	1.15	1.14	138	1897	0.91	0.86	0.86	3
1948	1.03	1.18	1.16	138	1896	1.20	0.97	1.00	3
1947	1.15	1.09	1.09	134	1895	0.90	0.98	0.97	3
1946	1.07	1.26	1.24	131	1894	1.19	0.83	0.87	3
1945	1.06	1.18	1.17	129	1893	1.03	0.76	0.79	3
1944	1.07	1.01	1.02	124	1892	0.88	0.91	0.91	3
1943	1.06	0.92	0.93	123	1891	1.17	0.68	0.73	3
1942	1.01	0.79	0.81	119	1890	0.72	1.11	1.07	2
1941	1.05	0.63	0.67	119	1889	0.93	0.84	0.84	118
1940	0.94	0.82	0.83	119	1888	0.88	0.97	0.96	112

Table 4

Dendrological scale spruce plantations of 7th group

Year	Indices			Count trees, pieces	Year	Indices			Count trees, pieces
	late wood	early wood	annual ring			late wood	early wood	annual ring	
1991	1.02	1.06	1.05	60	1939	0.91	0.82	0.84	77
1990	1.10	1.16	1.15	85	1938	0.92	0.92	0.96	69
1989	1.07	1.08	1.08	85	1937	0.92	0.96	0.96	67
1988	1.27	0.90	0.97	105	1936	0.90	0.95	0.94	60
1987	0.99	0.91	0.93	105	1935	0.98	0.97	0.97	56
1986	1.07	0.90	0.93	105	1934	0.94	1.07	1.05	55
1985	1.06	0.88	0.91	105	1933	1.07	1.11	1.09	52
1984	0.87	0.84	0.84	105	1932	1.04	1.02	1.02	49
1983	0.91	1.03	1.01	105	1931	0.97	0.96	0.95	45
1982	0.96	0.99	0.99	105	1930	1.00	0.98	0.97	45
1981	1.05	0.90	0.92	105	1929	0.86	0.94	0.93	42
1980	0.83	0.70	0.72	105	1928	0.99	0.85	0.87	40
1979	0.90	0.74	0.76	105	1927	1.08	1.10	1.08	33
1978	1.00	0.94	0.95	105	1926	1.07	1.05	1.06	31
1977	1.00	1.08	1.07	105	1925	0.98	1.10	1.11	31
1976	1.02	1.10	1.09	105	1924	1.16	1.25	1.20	28
1975	1.05	1.16	1.14	105	1923	1.15	1.24	1.19	27
1974	1.00	1.18	1.16	105	1922	1.36	1.11	1.19	25
1973	1.12	1.08	1.08	105	1921	1.32	1.13	1.21	24
1972	1.00	1.10	1.09	105	1920	1.05	1.06	1.06	22
1971	1.00	1.03	1.03	105	1919	1.11	1.15	1.12	20
1970	1.01	1.12	1.11	105	1918	1.18	0.97	0.85	15
1969	0.95	1.00	0.99	105	1917	0.92	0.79	0.82	13
1968	1.02	0.95	0.96	105	1916	0.68	0.79	0.79	11
1967	1.05	1.04	1.04	105	1915	0.69	0.82	0.81	10
1966	1.05	1.05	1.05	105	1914	0.79	0.91	0.90	10
1965	0.99	0.86	0.87	105	1913	0.81	0.77	0.79	9
1964	0.96	0.83	0.84	105	1912	0.67	0.88	0.86	8
1963	0.88	0.94	0.94	105	1911	0.75	0.75	0.76	8
1962	0.99	1.00	1.00	105	1910	0.78	0.70	0.72	8
1961	1.01	1.00	1.01	105	1909	0.59	0.57	0.58	8
1960	1.00	1.02	1.02	105	1908	0.47	0.41	0.42	7
1959	1.04	1.09	1.09	105	1907	0.97	0.62	0.67	6
1958	1.13	1.09	1.09	105	1906	1.14	0.89	0.93	6
1957	1.05	1.11	1.10	105	1905	0.97	0.80	0.83	6
1956	1.12	1.05	1.04	105	1904	0.96	1.16	1.13	5
1955	0.98	1.08	1.07	104	1903	1.45	0.76	0.86	5
1954	0.94	1.00	0.99	104	1902	1.17	0.70	0.77	5
1953	1.02	1.04	1.03	103	1901	1.03	1.08	1.07	4
1952	1.04	0.93	0.94	101	1900	1.22	1.73	1.66	4
1951	0.91	0.99	0.98	101	1899	1.10	1.86	1.75	4
1950	0.92	1.05	1.03	99	1898	1.58	1.23	1.28	4
1949	0.95	1.06	1.05	96	1897	1.27	1.24	1.24	4
1948	0.95	1.11	1.10	96	1896	1.38	1.28	1.29	4
1947	1.15	1.04	1.06	95	1895	0.89	1.29	1.24	4
1946	1.07	1.15	1.16	95	1894	0.90	0.94	0.94	4
1945	1.07	1.15	1.14	94	1893	0.80	0.86	0.86	4
1944	1.05	1.10	1.09	93	1892	1.01	0.94	0.95	4
1943	0.99	1.06	1.03	88	1891	0.81	0.90	0.89	4
1942	0.99	0.91	0.91	82	1890	0.62	0.90	0.86	4
1941	1.02	0.80	0.82	80	1889	0.73	0.89	0.86	4
1940	0.97	0.87	0.89	80	1888	1.15	0.78	0.83	4

Dendrological scale of spruce forests have a length of 104 years (1888–1991) (Table 2–4). Model material for their preparation is taken up in 75 plantations growing in all forest vegetation subzones of Belarus.

Analyzing the data obtained, it should be noted that during this period the index values in the spruce forests of the 5th group plantings ranged for late wood within 0.66–1.44, for early – 0.61–1.30, for tree-ring as a whole – 0.62–1.29.

In spruce 6th group index values fluctuated for late wood within 0.72–1.99, for early – 0.63–1.26, for tree-ring as a whole – 0.67–1.24.

In spruce 7th group index values fluctuated for late wood within 0.47–1.58, for early – 0.41–1.86, for tree-ring as a whole – 0.42–1.75.

Coefficients of variation of indices width of tree rings made of spruce plantations 5th group 13% for spruce 6th group – 11% for spruce 7th group – 18%, which corresponds to the lower rate of normal variation.

Conclusion. Dendrological scale contain tree-ring indices in general, as well as indices of the late and early wood. Greater variation in the width of the growth rings, characteristic of spruce forests of the 7th group, growing in semi-hydromorphic soils under conditions of excess moisture due to unstable water-air regime, which is formed under the influence of periodic droughts and is manifested in a sharp and significant decrease in the groundwater level. The above materials can be used for monitoring of plant communities.

References

1. Rusalenko A. I., Filon D. I. Ecological-floristic classification of spruce forests of Belarus. *Vestsi NAN Belarusi* [Conduct of the NAS of Belarus], series of Biological Sciences, 2010, no. 4, pp. 20–26 (In Russian).

2. Rusalenko A. I. *Lesa Belarusi: ekologiya, struktura, produktivnost'* [Belarusian forests: ecology, structure, productivity]. Minsk: Belarussian State Tecnological University Publ., 2012. 348 p.

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